Guideline:[1] Fortification of Rice with Vitamins and Minerals as a Public Health Strategy

Executive Summary

Fortification of staple foods, when appropriately implemented, can be an efficient, simple and inexpensive strategy for supplying additional vitamins and minerals to the diets of large segments of the population. Rice is cultivated in many parts of the world as it grows in diverse climates. Industrial fortification of rice with vitamins and minerals has been practiced for many years in several countries in the World Health Organization (WHO) Eastern Mediterranean Region, Western Pacific Region and Region of the Americas where rice is a staple consumed regularly in the preparation of many common local dishes.

Decisions about the types and amounts of nutrients to add to fortified rice are commonly based on the nutritional needs and gaps in dietary intake of the target populations; the usual level of consumption of rice; the sensory and physical effects of the fortificant on the rice kernels; the fortification processing used in the production of the fortified kernels; the availability and coverage of fortification of other staple food vehicles; the population consumption of vitamin and mineral supplements; the costs; the feasibility of implementation; and the acceptability to the consumers.

Rice kernels can be fortified with several micronutrients, such as iron, folic acid and other B-complex vitamins,[2] vitamin A and zinc – some are used for restitution of the intrinsic nutritional contents prior to milling and others are used for fortification purposes. Their bioavailability will depend, importantly, on the processing used in the production of the fortified kernels.

Purpose of the guideline

This guideline provides global, evidence-informed recommendations on the fortification of rice with micronutrients as a strategy to improve the health status of populations.

It aims to help Member States and their partners to make informed decisions on the appropriate nutrition actions to achieve the 2030 Sustainable Development Goals[3] and the global targets set in the *Comprehensive Implementation Plan on Maternal, Infant and Young Child Nutrition*.[4]

The recommendations in this guideline are intended for a wide audience including policy makers, their expert advisers and technical and program staff in ministries and organizations involved in the design, implementation and scaling up of nutrition actions for public health.

The guideline complements the WHO/FAO (Food and Agriculture Organization of the United Nations) *Guidelines on Food Fortification with Micronutrients*[5] and the Pan American Health Organization document, *Iron Compounds for Food Fortification: Guidelines for Latin America and the Caribbean 2002*.[6]

Summary of the evidence

A Cochrane systematic review on fortification of rice with vitamins and minerals for addressing micronutrient malnutrition included 16 studies (14,267 participants). The search strategy was conducted in 2012 and updated in 2017. Twelve were randomized controlled trials (5,167 participants) with 10 involving children in urban and rural settings and two studies involving non-pregnant non-lactating women. Four studies were controlled before-and-after studies (9,100 participants). The 16 selected studies reported fortification with iron. Of these, six studies fortified rice with iron only; in 10 studies, other micronutrients were added (iron, zinc, vitamin A and folic acid). Five studies provided other B-complex vitamins. The control for all trials was unfortified rice. The iron content ranged from 0.2 mg to 112.8 mg/100 g uncooked rice, given for a period varying from two weeks to 48 months.

The review showed that the provision of rice fortified with vitamins and minerals including iron, when compared with unfortified rice, probably improves iron status by reducing the risk

of iron deficiency by 35% and increasing the average concentration of hemoglobin by almost 2 g/L, but may not make a difference to the risk of anemia in the general population of those aged over two years. When the fortification of rice includes vitamin A it may reduce both iron deficiency and vitamin A deficiency. When fortification includes folic acid, fortified rice may slightly increase serum folate concentrations.

In addition to the direct and indirect evidence (vitamins and minerals delivered using food vehicles other than rice) and its overall quality, other considerations were taken into account by the guideline development group to define the direction and strength of the recommendations. They included values and preferences of the populations related to fortification of rice in different settings, trade-off between benefits and harms, costs and feasibility.

For developing the recommendations, the guideline development group considered the certainty of the existing evidence,[7] values and preferences, costs, baseline prevalence of anemia and/or other nutritional deficiencies, equity and the feasibility of implementation.

Recommendations

- Fortification of rice with iron is recommended as a public health strategy to improve the iron status of populations in settings where rice is a staple food.[8] (*strong recommendation,*[9] *moderate-certainty evidence*).
- Fortification of rice with vitamin A may be used as a public health strategy to improve the iron status and vitamin A nutrition of populations (*conditional recommendation*,[10] *low- certainty evidence*).
- Fortification of rice with folic acid may be used as a public health strategy to improve the folate nutritional status of populations (*conditional recommendation*,[11] *very low-certainty evidence*).

Remarks

The remarks in this section are intended to give some considerations for implementation of the recommendations, based on the discussion of the guideline development group.

- The number and amounts of nutrients should be adapted according to the needs of the country. If other fortification programs with other food vehicles (i.e., wheat flour, maize flour or corn meal) and other micronutrient interventions are jointly implemented effectively, these suggested fortification levels need to be adjusted downwards as necessary. A combined fortification strategy using multiple vehicles appears to be a suitably effective option for reaching all segments of the population.
- There are several methods available for the fortification of rice. The method chosen depends on the local technology available, costs, and other preferences. The process of adding nutrients to rice through dusting reduces the number of nutrients consumed in settings where rice is commonly washed before cooking. In particular, washing and cooking practices among a population are important considerations in selecting a method for fortification of rice. For example, rinse-resistant methods to ensure that nutrients are retained after washing will be important if rice is commonly washed before cooking.
- Rice milling results in the loss of a significant proportion of B vitamins and minerals that are found predominately in the outer germ and bran layers. Nutrient losses during milling can be minimized by a process called parboiling, in which raw rice is soaked in water and partially steamed before drying and milling, resulting in some of the B vitamins migrating further into the grain.
- Since some of the fat- and micronutrient-rich bran layers are removed during rice milling, the restoration of thiamine, niacin, riboflavin and vitamin B_6 in the fortification profile should remain a regular practice in fortification.
- The prevalence of depletion and deficiency of vitamin B_{12} is high in all age groups, reaching 50% in some countries. The inclusion of vitamin B_{12} is recommended when staples are fortified with folic acid to avoid the masking effect of folic acid on vitamin B_{12} deficiency.
- Fortification of rice with iron has been a challenge since most of the bioavailable iron powders used in food fortification are colored, which produces changes in the aspect of fortified kernels compared to unfortified ones. Ferric pyrophosphate has been the choice for rice fortification because it is a white powder, although its bioavailability is low.[12] In human absorption studies, the addition of enhancing compounds such as citric acid/trisodium citrate mixtures has been linked to an increase in iron absorption from ferric pyrophosphate.[13]
- Mandatory rice-fortification programs can only be effective if they are properly implemented and legislation is enforced.
- Food fortification should be guided by national standards, with quality assurance and quality control systems to ensure quality fortification. Continuous program monitoring should be in place as part of a process to ensure high-quality implementation. Monitoring of consumption patterns and evaluation of micronutrient status in the population can inform adjustment of fortification levels over time.
- Rice fortification on a national scale requires a large, cost-effective and sustainable supply of fortified kernels.
- In malaria-endemic areas, the provision of iron through rice fortification as a public health strategy should be done in conjunction with public health measures to prevent, diagnose and treat malaria.

- Behavior-change communication strategies may be necessary for overcoming barriers and creating and maintaining demand for fortified rice.

References and notes

1. This publication is a World Health Organization (WHO) guideline (Guideline: fortification of rice with vitamins and minerals as a public health strategy. Geneva: World Health Organization; 2018. Licence: CC BY-NC-SA 3.0 IGO Executive summary, pages 1-4. Geneva: World Health Organization; 2018. Accessed from: www.who.int/nutrition/publications/guidelines/rice-fortification/en/ on 18 June 2018). A WHO guideline is any document, whatever its title, containing WHO recommendations about health interventions, whether they be clinical, public health or policy interventions. A recommendation provides information about what policymakers, healthcare providers or patients should do. It implies a choice between different interventions that have an impact on health and that have ramifications for the use of resources. All publications containing WHO recommendations are approved by the WHO Guidelines Review Committee.
2. The B-complex vitamins include B_1, thiamine; B_2, riboflavin; B_3, niacin; B_6, pyridoxine; B_9, folate; and B_{12}, cyanocobalamin. Thiamine, riboflavin, niacin and folic acid are commonly referred to by name and their names are used throughout this document; the others are referred to by vitamin number.
3. Sustainable Knowledge Development Platform. Sustainable Development Goals (sustainabledevelopment.un.org/sdgs).
4. Comprehensive implementation plan on maternal, infant and young child nutrition. Geneva: World Health Organization; 2014 (WHO/ NMH/NHD/14.1; apps.who.int/iris/bitstream/handle/10665/113048/WHO_NMH_NHD_14.1_eng.pdf?sequence=1).
5. Allen L, de Benoist B, Dary O, Hurrell R, eds. Guidelines on food fortification with micronutrients. Geneva: World Health Organization and Food and Agriculture Organization of the United Nations; 2006 (apps.who.int/iris/bitstream/handle/10665/43412/9241594012_ eng.pdf?sequence=1).
6. Dary O, Freire W, Kim S. Iron compounds for food fortification: guidelines for Latin America and the Caribbean 2002. Nutr Rev 2002;60(7):S50–61. doi:10.1301/002966402320285218.
7. The Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach defines the overall rating of confidence in the body of evidence from systematic reviews as the extent to which one can be confident of the effect estimates across all outcomes considered critical to the recommendation. Each of the critical outcomes had a confidence rating based on certainty of evidence – high, moderate, low, or very low. High-certainty evidence indicates confidence that the true effect lies close to that of the estimate of the effect. Moderate-certainty evidence indicates moderate confidence in the effect estimate and that the true estimate is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different. Low-certainty evidence indicates that confidence in the effect estimate is limited and the true effect may be substantially different from the estimate of the effect. Very low-certainty evidence indicates very little confidence in the effect estimate and the true effect is likely to be substantially different from the estimate of effect.
8. A staple food, or simply a staple, is a food that is consumed regularly and provides an important proportion of the energy (calories) and nutrient requirements. Its preparation is variable in different contexts and is closely linked to the most available foods in each place.
9. A strong recommendation is one for which the guideline development group is confident that the desirable effects of adherence outweigh the undesirable effects. Implications of a strong recommendation are that most people in these settings would desire the recommended fortification of rice with iron and only a small proportion would not. For policymakers, a strong recommendation indicates that the recommendation can be adopted as policy in most situations.
10. A conditional recommendation is one for which the guideline development group concludes that the desirable effects of adherence probably outweigh the undesirable effects, although the trade-offs are uncertain. Implications of a conditional recommendation for populations are that while many people would desire fortification of rice with vitamins and minerals, a considerable proportion would not. With regard to policymakers, a conditional recommendation means that there is a need for substantial debate and involvement from stakeholders before considering the adoption of fortification of rice with these vitamins and minerals in each setting.
11. A conditional recommendation is one for which the guideline development group concludes that the desirable effects of adherence probably outweigh the undesirable effects, although the trade-offs are uncertain. Implications of a conditional recommendation for populations are that while many people would desire fortification of rice with vitamins and minerals, a considerable proportion would not. With regard to policymakers, a conditional recommendation means that there is a need for substantial debate and involvement from stakeholders before considering the adoption of fortification of rice with these vitamins and minerals in each setting.
12. Moretti D, Zimmermann MB, Wegmüller R, et al. Iron status and food matrix strongly affect the relative bioavailability of ferric pyrophosphate in humans. Am J Clin Nutr 2006;83(3):632–8. doi:10.1093/ajcn.83.3.632.
13. Hackl L, Cercamondi C, Zeder C, et al. Cofortification of ferric pyrophosphate and citric acid/trisodium citrate into extruded rice grains doubles iron bioavailability through in situ generation of soluble ferric pyrophosphate citrate complexes. Am J Clin Nutr 2016;103(5):1252–9. doi:10.3945/ajcn.115.128173.